DOE Hydrogen and Fuel Cells Program Record	
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Title: Revised Portable Power Fuel Cell Targets	
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Research and development targets for fuel cells deployed in portable power applications have been updated to the values listed in Tables 1–3.

Table 1. Fuel cell system targets for portable power applications under 2 W[1]

	Units	2011 Status	2013	2015
Specific Power [2]	W/kg	5	8	10
Power Density [2]	W/L	7	10	13
Specific Energy [2,3]	Wh/kg	110	200	230
Energy Density [2,3]	Wh/L	150	250	300
Cost [4]	$/system	150	130	70
Durability [5,6]	hours	1500	3000	5000
Mean Time Between Failures [6,7]	hours	500	1500	5000

Table 2. Fuel cell system targets for 10 – 50 W portable power applications[1]

	Units	2011 Status	2013	2015
Specific Power [2]	W/kg	15	30	45
Power Density [2]	W/L	20	35	55
Specific Energy [2,3]	Wh/kg	150	430	650
Energy Density [2,3]	Wh/L	200	500	800
Cost [4]	$/W	15	10	7
Durability [5,6]	hours	1500	3000	5000
Mean Time Between Failures [6,7]	hours	500	1500	5000

Table 3. Fuel cell system targets for 100 – 250 W portable power applications[1]

	Units	2011 Status	2013	2015
Specific Power [2]	W/kg	25	40	50
Power Density [2]	W/L	30	50	70
Specific Energy [2,3]	Wh/kg	250	440	640
Energy Density [2,3]	Wh/L	300	550	900
Cost [4]	$/W	15	10	5
Durability [5,6]	hours	2000	3000	5000
Mean Time Between Failures [6,7]	hours	500	1500	5000

[1] These targets are technology neutral and make no assumption about the type of fuel cell technology or type of fuel used. In addition to meeting these targets, portable power fuel cells are expected to operate safely, providing power without exposing users to hazardous or unpleasant emissions, high temperatures, or objectionable levels of noise. Portable power fuel cells are also expected to be compatible with the requirements of portable electronic devices, including operation under a range of ambient temperature, humidity, and pressure conditions, and exposure to freezing conditions, vibration, and dust. They should be capable of repeatedly turning off and on, and should have turndown capabilities required to match the dynamic power needs of the device. For widespread adoption, portable power fuel cell systems should minimize lifecycle environmental impact through the use of reusable fuel cartridges, recyclable components, and low-impact manufacturing techniques.

[2] This is based on rated net power of the total fuel cell system, including fuel tank, fuel, and any hybridization batteries. In the case of fuel cells embedded in other devices, only device components required for power generation, power conditioning, and energy storage are included. Fuel capacity is not specified, but the same quantity of fuel must be used in calculation of specific power, power density, specific energy, and energy density.

[3] Efficiency of 30% in 2013 and 35% in 2015 is recommended to enable high specific energy and energy density.

[4] Cost includes material and labor costs required to manufacture the fuel cell system and any required auxiliaries (e.g., refueling devices). Cost is defined at production rates of 50,000, 25,000 and 10,000 units per year for <2, 10 – 50, and 100 – 500 W units, respectively.

[5] Durability is defined as the time until the system rated power degrades by 20%, though for some applications higher or lower levels of power degradation may be acceptable.

[6] Testing should be performed using an operating cycle that is realistic and appropriate for the target application, including effects from transient operation, startup and shutdown, and off-line degradation.

[7] Mean Time Between Failures (MTBF) includes failures of any system components that render the system inoperable without maintenance.

Supporting Information: On June 1, 2010, DOE issued a request for information (RFI), DE-FOA-0000373, soliciting comments from stakeholders and the research community on proposed technical targets for portable power fuel cell systems. The targets proposed in the RFI, as detailed in Tables 4 – 6, were adapted from DOE's existing fuel cell targets for consumer electronics, using input from DOE consultants and fuel cell developers.

Stakeholders and researchers submitted recommendations to DOE in response to the RFI. Revisions to the proposed targets were made using information provided in the RFI responses, as well as information obtained in subsequent discussions with respondents. The new 2015 targets were selected to represent values at which fuel cells would be widely competitive with conventional portable power technology (batteries), while the 2013 targets represent interim values at which niche commercialization would be possible.

Table 4. Proposed performance, durability, and cost targets for fuel cell systems for portable power applications under 2 W (*e.g.* portable chargers)

	Units	Estimated 2009 Status	2011	2013
Specific Power [1]	W/kg	3	5	10
Power Density [1]	W/L	5	7	15
Energy Density [2]	Wh/L	140	200	300
Cost [3]	$/system	150	125	100
Durability [4]	Hours	2000	3500	5000

Table 5. Proposed performance, durability, and cost targets for fuel cell systems for portable power applications between 2 W and 25 W (e.g. portable media players)

	Units	Estimated 2009 Status	2011	2013
Specific Power [1]	W/kg	14	25	50
Power Density [1]	W/L	13	25	50
Energy Density [2]	Wh/L	200	400	700
Cost [3]	$/W	11	10	6
Durability [4]	Hours	900	3500	5000

Table 6. Proposed performance, durability, and cost targets for fuel cell systems for portable power applications between 25 W and 250 W (*e.g.* laptop computers and outdoor recreational power supplies)

	Units	Estimated 2009 Status	2011	2013
Specific Power [1]	W/kg	25	40	50
Power Density [1]	W/L	14	70	100
Energy Density [2]	Wh/L	440	650	1000
Cost [3]	$/W	20	6	3
Durability [4]	Hours	2000	3500	5000

[1] Based on total fuel cell system excluding fuel tank, fuel, and any hybridization batteries.
[2] Based on total fuel cell system including sufficient fuel for 5 hours of operation at system rated power.
[3] Factory cost defined at 25,000 units per year production.
[4] Point at which the system rated power degrades by >20%.

The following changes were made to the target tables:

- Power ranges were narrowed, as recommended by several RFI respondents. Values of < 2, 10 – 50 , and 100 – 250 W were chosen.
- A specific energy target was added, following the request of several RFI respondents. This target is, strictly speaking, not necessary – specification of specific power, power density, and energy density implicitly specifies specific energy – but the target has been included for completeness.
- A mean time between failures (MTBF) target was added to account for system failures that are not captured by the durability target. Long-term target values were set to match durability target values, while short-term target values represent a reasonable progression from current status to the long-term targets.

The following changes were made to the target table footnotes:

- The footnotes were clarified to specify that all power levels refer to net system power.
- The targets were specified to be fuel-neutral and technology-neutral.

- Text was added to the footnotes to specify several required characteristics of portable power fuel cells that are not captured in the targets. These include acceptable levels of noise and emissions, hazard-free operation, ability to operate in a manner compatible with portable electronic devices (including the ability to turn off and on and to turn down power output), and ability to operate under a range of ambient conditions.
- The annual manufacturing volume specified for use in cost projections was increased to 50,000 units/year for the < 2 W targets, and decreased to 10,000 units/year for the 100 – 250 W targets. These changes follow recommendations from RFI respondents, and are considered to be representative of a likely early market introduction scenario.
- The footnotes were changed to specify that system cost includes the cost of any auxiliary components, such as refueling devices, if required.
- The fuel cell system definitions used in specific power, power density, specific energy, and energy density targets were modified to create a single definition for all targets. The footnote now specifies that all system components associated with power generation, power conditioning, and energy storage are included in the system definition. The targets no longer specify the quantity of fuel to be included, but the need to use the same quantity of fuel in specific power, power density, specific energy, and energy density calculations is emphasized.
- The footnotes on durability and MTBF were modified to indicate that testing should be performed using an operating cycle that is realistic and appropriate for the target application, including effects of off-line degradation.

Additional comments:

- DOE has chosen not to specify an operating cycle for use in durability and MTBF measurements. Given that different applications of portable power fuel cells will show wide variation in operating profiles, selection of an operating cycle is best left to the discretion of developers.
- DOE has opted against making any specification of the fuel type or the fuel cell technology type, since the targets were designed to be fuel neutral and technology neutral. Arguments in support of DOE's decision were provided in the RFI responses.
- Efficiency is already implicitly addressed through the specific energy and energy density targets, which are unlikely to be achieved without high efficiency operation. However, a footnote was added to indicate that achievement of 30% and 35% efficiency in 2013 and 2015, respectively, is recommended to enable high specific energy and high energy density.
- At this time, DOE has chosen not to specify component-level targets. While such targets would be valuable, they would require specification of fuel type and fuel cell technology type, and therefore are best treated as a separate set of targets than the fuel-neutral and technology-neutral targets listed above.